Storage of potato tubers under water. Preliminary investigations

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Summary

Potato tubers stored under water at 1 °C do not accumulate sugars. The addition of aseptic agents (hydrogen peroxide, thymol) allows them to be stored without any microbial spoilage. During storage for up to 8 weeks the tubers were acceptable as a food product. Because of the possibility of the practical application of this method of storage, it is planned to investigate it in full detail.

Introduction

The proper storage of potato tubers during winter and spring is a continual concern of technologists and an aim of scientific investigations in many countries. The difficulty depends on the applying of such conditions of storage as to ensure the minimal losses by evaporation, respiration and sprouting as well as microbial spoilage and to prevent the sugar accumulation. It is well known that the best means of decreasing the metabolic processes in the tubers is to keep them at a low temperature near the freezing point. This temperature, however, stimulates breakdown of starch and sugar accumulation. To lower the level of sugars after cold storage the processors employ the so-called reconditioning of potato tubers. This process, however, causes increased losses by evaporation and respiration and very often sprouting.

To overcome these difficulties we have tested in our laboratory a new way of potato tuber storage, namely to keep them under water at a low temperature and in aseptic conditions.

Materials and methods

Two Polish varieties (*Flisak* and *Nina*), one American variety (*Kennebec*) and Polish strain 42431 have been tested in our experiments. The tubers have been washed in running water and the medium sized tubers have been chosen. Part of these have been stored in the store room under controlled conditions (constant temperature 1 °C and the relative humidity 85–90%) and part have been placed in glass containers (about 5 l capacity each) and immersed in water. In the first experiment the tubers of *Flisak*, *Nina* and *Kennebec* varieties were immersed in tap water. In the second experiment the strain 42431 was immersed in distilled water with added hydrogen peroxide (final concentra-

tion 0.1–0.13%) or with thymol (a few crystals in every container). The containers were placed in the store room at 1 °C.

In the first experiment the tubers were analysed on November 4, 1969 (the start of experiment), December 2, 1969 (after 4 weeks' storage under water) and January 7, 1970 (after 9 weeks' storage under water). The results of sugar analyses were compared with those on tubers stored at 1 °C in air.

In the second experiment the tubers were analysed on February 2, 1970 (the start of experiment), March 2, 1970 (after 4 weeks' storage under water) and April 1, 1970 (after 8 weeks' storage under water). The results of sugar analyses were compared, as above, with those on the tubers stored in a normal way at 1 °C.

Before starting the experiment at the low temperature the tubers were stored in a cellar under uncontrolled conditions (temperature varying from 6° to 12 °C).

The level of hydrogen peroxide was checked every third day by titration with 0.1 N $KMnO_4$. The losses of hydrogen peroxide were made good by the addition of the necessary amount of 30% H_2O_2.

The stored tubers were analysed for glucose, fructose and sucrose by the method described previously (Samotus and Kujawski, 1969; Samotus et al., 1969 a and b). The results were calculated as percentage fresh weight.

Results

Experiment 1

The changes in total sugars, sucrose and reducing sugars, in potato tubers stored in air and under water in this experiment, are shown in Table 1. The potatoes stored in air accumulated considerable amounts of sugars. One can see the differences between the varieties in this respect. On the other hand, storage under water prevented the sugar accumulation and one can even observe a decrease of total sugars. There was a considerable increase of reducing sugars in potatoes stored in air, while the level decreased during storage under water. It is interesting to note, however, that after 4 weeks' storage under water the varieties *Nina* and *Flisak* accumulated reducing sugars. The increase of sucrose in tubers stored in air was not so marked as in the case of reducing sugars, but it was quite distinct. The amount of sucrose in the tubers stored under water fell to a very low level.

After 8 weeks of storage of tubers under water the first symptoms of spoilage were noticed. After 9 weeks all the samples started to rot, so the experiment had to be discontinued and a new one started using agents to prevent the putrefaction.

Experiment 2

Because of the lack of good and healthy material the analyses given for the tubers stored in air are those done on tubers at the time of the first experiment. There is some objection to this in that the sweetening behaviour might have changed between November 4 and February 2, but such a change is unlikely to be of importance in com-

Table 1. Changes in the sugar content (%) of 3 varieties stored at 1 °C in air and under water.

Variety	Type of sugar	Not stored	Stored for 4 weeks		Stored for 9 weeks	
			in air	under water	in air	under water
Flisak	Glucose	0.48	1.01	0.69	1.17	0.42
	Fructose	0.30	0.99	0.31	2.10	0.16
	Reducing sugars	0.78	2.00	1.00	3.27	0.58
	Sucrose	0.22	0.56	0.01	0.34	0.02
	Total sugars	1.10	2.56	1.01	3.61	0.60
Nina	Glucose	0.17	0.21	0.23	0.31	0.09
	Fructose	0.09	0.52	0.17	1.37	0.01
	Reducing sugars	0.26	0.73	0.40	1.68	0.10
	Sucrose	0.24	0.55	0.06	0.80	0.03
	Total sugars	0.50	1.28	0.46	2.48	0.13
Kennebec	Glucose	0.24	0.56	0.20	0.83	0.18
	Fructose	0.14	0.81	0.12	2.00	0.02
	Reducing sugars	0.38	1.37	0.32	2.83	0.20
	Sucrose	0.12	0.43	0.04	0.59	0.05
	Total sugars	0.50	1.80	0.36	3.42	0.25

parison with the effect of storage under water. The difference between the analyses after 0 weeks in air and under water respectively, given in Table 2, represents the change in sugar content during the uncontrolled cellar storage of the tubers used for the latter between November 4 and February 2. As will be seen, these changes were not large. The analyses of strain 42431 have been chosen to illustrate the results of this experiment because of the great sucrose accumulation during cold storage in air.

The results of the second experiment are shown in Table 2 and confirm those of the

Table 2. Changes in sugar content (%) of strain 42431 stored at 1 °C in air and under water with addition of aseptic agents.

Type of sugar	Not stored		Stored for 4 weeks			Stored for 8 weeks		
	in air	under water	in air	under water (H_2O_2 added)	under water (tyhmol added)	in air	under water (H_2O_2 added)	under water (thymol added)
Glucose	0.16	0.17	0.07	0.25	0.32	0.02	0.41	0.32
Fructose	0.14	0.08	0.58	0.13	0.17	1.60	0.28	0.22
Reducing sugars	0.30	0.25	0.65	0.38	0.49	1.62	0.69	0.54
Sucrose	0.32	0.50	2.71	0.32	0.32	2.33	0.06	0.02
Total sugars	0.62	0.75	3.36	0.70	0.81	3.95	0.75	0.56

first one. The tubers stored in air accumulated a lot of sugars, whereas those stored under water did not. There are, however, differences in detail. For example, in contradistinction to the first experiment one can see the gradual increase of reducing sugars in tubers stored under water. Because of the constant level of the total sugars during the experiment the increase of reducing sugars can be explained as a result of sucrose decomposition. Simultaneously, one can see a tremendous increase of sucrose accumulation during the storage of tubers in air. The strain 42431 accumulates, when stored in air considerable amounts of fructose, while the level of glucose drops. Storage under water causes a gradual increase of glucose as well as of fructose.

Conclusions

The storage of potato tubers under water prevents sugar accumulation at 1 °C. This is similar to the effect of anaerobic conditions observed previously (Samotus and Schwimmer, 1963). According to Burton's investigations (Burton, 1950) the diffusion of oxygen in water is 100,000 times slower than in air. That is the reason that after immersing the tubers in water, the tissue achieves in a short time an anaerobic state.

The other characteristic feature of the storage under water is the decomposition of sucrose to reducing sugars (glucose and fructose).

In spite of the low temperature (1 °C) the tubers immersed in water are susceptible to microbial spoilage. It is possible, however, to avoid this by the addition of some aseptic agents as for example hydrogen peroxide or thymol.

As for the macroscopic observations one can state that the tubers stored under water have not shown any negative organoleptic changes. They were in full turgor and the colour of the flesh was characteristic for the respective variety. The tubers stored in hydrogen peroxide solution were acceptable for consumption after boiling.

Because of a practical significance of this kind of potato tuber storage extensive investigations have been started this year in our laboratory. It is important to examine longer periods of storage under water, to try other aseptic agents as well as to examine the acceptability of the tubers for processing and consumption. These investigations will be performed in conjunction with complementary investigations at the A. R. C. Food Research Institute, Norwich, England.

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